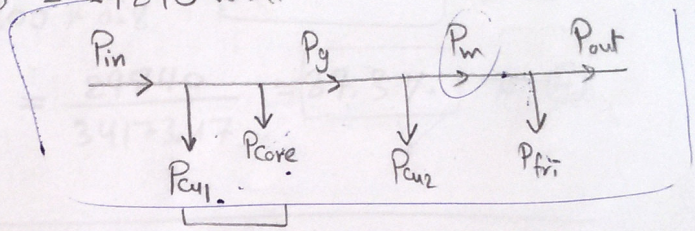
Sheet (4)

3-ph Induction Motor

① $P_{out} = 40 hp$, $V_1 = 3300 V$, $50 Hz$, $P = 4$, 3-ph, Star Conn.
$S = 2\%$, $P.f._1 = 0.8$ lag at Full load.
$P_{cu1} = 1000 W$, $P_{core} = 1500 W$, $P_{fri} = 1200 W$
(1 hp = 746 watt)
Req: at Full load ① N ② I_1 ③ P_{cu2} ④ η

Solution

$\because P_{out} = 40 hp = 40 * 746 = 29840$ watt



(Power flow).

$\because N_s = \frac{120 f}{P} = \frac{120 * 50}{4}$

$\therefore N_s = 1500$ rpm

$\because N = N_s(1 - S)$, $S = \frac{2}{100} = 0.02$

$\therefore N = 1500(1 - 0.02) = 1470$ rpm

$\therefore N = 1470$ rpm # ①

$\because P_{in} = P_1 = \sqrt{3} V_1 I_1 P.f._1$

ولإيجاد التيار I_1 يلزم إيجاد P_{in} والتي يتم حسابها من Power flow لسابقه

$P_m = P_{out} + P_{fri} = 29840 + 1200 = 31040 W$

$\because$ $P_g : P_{cu2} : P_m$
$1 : S : 1 - S$ from Power relationships

$\therefore P_{cu2} = P_m \left(\frac{S}{1-S} \right) = 31040 * \left(\frac{0.02}{1 - 0.02} \right)$

$\therefore P_{cu2} = 633.47 W$ # ③

$\therefore P_g = \frac{P_{cu2}}{S}$

$\therefore P_g = \frac{633.47}{0.02} = 31673.47\ W$

$\therefore P_{in} = P_g + P_{\substack{stator \\ losses}} = 31673.47 + (1000 + 1500)$ (P_{cu1}, Core)

$\therefore P_{in} = 34173.47\ W$

$\therefore P_{in} = \sqrt{3}\, V_1 I_1 P.f_1$

$\therefore I_1 = \frac{34173.47}{\sqrt{3} * 3300 * 0.8} = \boxed{7.4735\ A}$ # ②

$\eta\% = \frac{P_{out}}{P_{in}} * 100 = \frac{29840}{34173.47} = \boxed{87.3\%}$ # ④

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② 3-ph, $V_1 = 500\ v$, $f = 50\ Hz$, $P = 6$ Poles, Star Conn.

$P_{out} = 20\ hp$ at $N = 950\ rpm$, $P.f_1 = 0.85$ lag, $P_{fri} = 1\ hp$

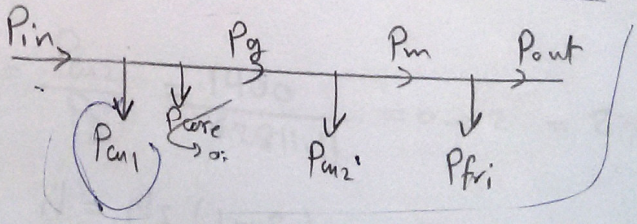
$P_{\substack{stator \\ loss}} = 1500\ w = P_{cu} + P_{core}$ (neglect).

Req: ① Slip ② P_{cu2} ③ I_1

Solution

$S = \frac{N_s - N}{N_s}$, $N_s = \frac{120 * f}{P} = \frac{120 * 50}{6} = 1000\ rpm$

$\therefore S = \frac{1000 - 950}{1000} = \boxed{0.05 = 5\%}$ # ①



$P_{out} = 20 * 746 = 14920\ w$

$P_{fri} = 1 * 746 = 746\ w$

$\therefore P_m = P_{out} + P_{fri} = 15666\ w$

$\because P_g : P_{cu2} : P_m$

$1 : S : 1 - S$

$P_{cu2} = P_m \left(\frac{S}{1-S}\right) = 15666 * \left(\frac{0.05}{1-0.05}\right) = \boxed{824.526\ W}$ #②

$\therefore P_g = \frac{P_{cu2}}{S} = \frac{824.526}{0.05} = 16490.526\ W$

$\therefore P_{in} = P_g + P_{stator\ loss} = 16490.526 + 1500 = 17990.526\ W$

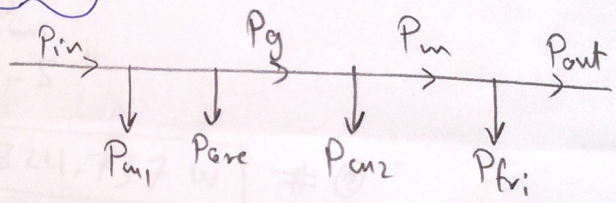
$\therefore P_{in} = \sqrt{3}\, V_l I_l P.f_l$

$\therefore I_l = \frac{17990.526}{\sqrt{3} * 500 * 0.85} = \boxed{24.44\ A}$ #③

③ 3-ph, $f = 50\ Hz$, $P_{out} = 80\ hp$, $P = 4$ poles, star Conn. at rated condition $\eta = 90\%$, $P_{core} = 1500\ W$, $P_{cu1} = 2000\ W$, $P_{cu2} = 1400\ W$. Req: ① P_{in} ② P_g ③ N

Solution

$\therefore \eta = 90\% = 0.9 = \frac{P_{out}}{P_{in}}$



$\therefore P_{out} = 80 * 746 = 59680\ W$

$\therefore P_{in} = \frac{P_{out}}{\eta} = \frac{59680}{0.9} = \boxed{66311.11\ W}$ #①

$\therefore P_{in} = P_g + P_{stator\ losses}$ $\quad \therefore P_g = P_{in} - P_{stator\ losses} = 66311.11 - (2000 + 1500)$ (P_{cu1}, P_{core})

$\therefore \boxed{P_g = 62811.11\ W}$ #②

$\therefore P_g = \frac{P_{cu2}}{S}$ $\quad \therefore S = \frac{P_{cu2}}{P_g} = \frac{1400}{62811.11} = 0.02 = 2\%$

$\therefore S = \frac{N_s - N}{N}$ $\quad \therefore N = N_s (1 - S)$

$\therefore N_s = \frac{120 f}{P} = \frac{120 * 50}{4} = 1500\ rpm$

$\therefore N = 1500(1 - 0.02) = \boxed{1466.56\ rpm}$ #

③

, $V_1 = 400\,V$, $f = 50$, $P = 6$, star Conn., $P_{out} = 20\,hp$
$= 950\,rpm$, $P.f_1 = 0.85$, $P_{fri} = 750\,W$, $P_{core} = 500\,W$
$P_{cu_1} = 1000\,W$

Req: ① S ② P_{cu_2} ③ I_1

Solution

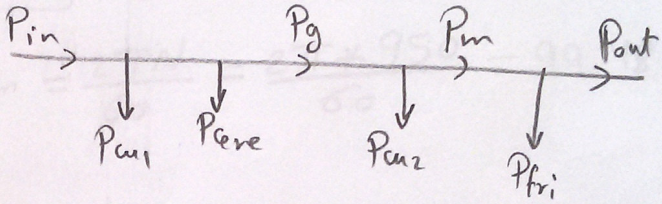
$$S = \frac{N_s - N}{N_s}$$

$$N_s = \frac{120f}{P} = \frac{120 * 50}{6} = 1000\,rpm$$

$$\therefore S = \frac{1000 - 950}{1000} = \boxed{0.05 = 5\%} \quad \# ①$$

$P_{out} = 20 * 746 = 14920\,W$

$P_{fri} = 750\,W$



$$P_m = P_{out} + P_{fri} = 14920 + 750 = 15670\,W$$

$$\therefore P_g : P_{cu_2} : P_m$$
$$1 : S : 1 - S$$

$$\therefore P_{cu_2} = P_m \left(\frac{S}{1-S}\right) = \boxed{824.737\,W} \quad \# ②$$

$$P_g = \frac{P_{cu_2}}{S} = \boxed{16494.737} \quad \#$$

$$P_{in} = P_g + P_{stator\ loss} = 16494.737 + (500 + 1000)$$
(P_{core}, P_{cu_1})

$$\therefore P_{in} = 17994.7368\,W$$

$$\therefore P_{in} = \sqrt{3}\, V_1\, I_1\, P.f_1$$

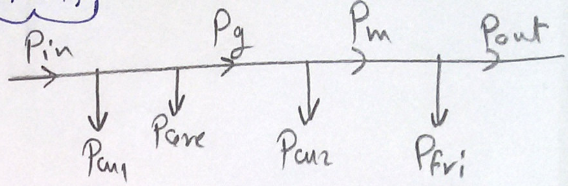
$$\therefore I_1 = \frac{17994.7368}{\sqrt{3} * 400 * 0.85} = \boxed{30.556\,A} \quad \# ③$$

3-ph, star Conn. $f = 50\ Hz$, $P = 6$, $V_1 = 380\ V$, $N = 950$ rpm

$T_{out} = 25\ Nm$, $(P_{cu1} + P_{core}) = 350\ W$, $P_{fri} = 250\ W$

$P.f._1 = 0.7$ lag. Req: (1) S (2) P_{cu2} (3) P_g (4) I_1 (5) η

Solutions



$S = \frac{N_s - N}{N_s}$, $N_s = \frac{120 * 50}{6}$

$\therefore N_s = 1000\ rpm$

$\therefore S = \frac{1000 - 950}{1000} = 0.05 = 5\%$ # (1)

$\because P_{out} = T_{out} * W_m$, $W_m = \frac{2\pi N}{60} = \frac{2\pi * 950}{60} = 99.48\ \frac{Rad}{sec}$

$\therefore P_{out} = 2487.1\ W$

$P_m = P_{out} + P_{fri} = 2737.1\ W$

$P_{cu2} = P_m \left(\frac{S}{1-S}\right) = 144.057\ W$ # (2)

$P_g = \frac{P_{cu2}}{S} = 2881.151$ # (3)

$P_{in} = P_g + P_{stator\ loss} = 2881.151 + (350) = 3231.151\ W$

$P_{in} = \sqrt{3}\, V_1 I_1\, P.f._1$ $\therefore I_1 = \frac{3231.151}{\sqrt{3} * 380 * 0.7} = 7.013\ A$ # (4)

$\%\eta = \frac{P_{out}}{P_{in}} * 100 = 76.97\%$ # (5)

(6) → اسألة (2) عام